

PATENT APPLICATION

Docket No.: D426

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Title: Dual Code Spread Spectrum Communication System

SPECIFICATION

Statement of Government Interest

The invention was made with Government support under contract No. F04701-00-C-0009 by the Department of the Air Force. The Government has certain rights in the invention.

Field of the Invention

The invention relates to the field of direct sequence spectrum spreading (DSSS) communications systems. More particularly, the present invention relates to DSSS communications for selectively communicating from a transmitter to a select portion of a group of receivers using switched spreading codes.

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Background of the Invention

Spread spectrum communication systems use direct sequence spread spectrum (DSSS) codes for spectrum spreading channel signals communicated over respective communication channels and over a common channel bandwidth. Prior to transmission, an input signal having a narrow frequency spectrum, is spectrum spread by mixing the input signal with the DSSS code for providing a spread spectrum channel signal that has a spread spectrum extending in frequency over a wide channel bandwidth. The power spectra density of the communicated channel signal is spread over the channel bandwidth and is difficult to acquire without advance knowledge of the spreading code. As such, the communication system uses code division signaling for maintaining cochannel isolation of the multiple channel signals communicated over the channel bandwidth. Signal components of a channel signal are spread over the channel bandwidth providing low power components across the bandwidth rendering the isolation and reception of the input signal difficult without advance knowledge of the spreading code for correlation with the channel signal of interest. In order to reconstitute the spectrum spread signal upon reception, the channel signal is despread by correlating the received channel signal by a replica code generated in the receiver.

In a transmitter, spectrum spread channel signals are superimposed as an output signal that modulates a carrier for communicating by code division a plurality of channel signals,

1 each of which is spectrum spread by the respective spreading
2 code. Hence, each channel uses a respective spreading code, and
3 hence, each receiver is equipped with a respective spreading
4 code used for isolating a respective channel signal so that
5 each receiver can acquire one and only one respective channel
6 signal. During acquisition in the receiver, code phase is
7 determined using the autocorrelation properties of the
8 spreading code. When the receiver replica code is phase shifted
9 in time to coherently match the code phase of the incoming
10 channel signal, the signal is reconstituted and can be detected
11 during code phase lock. When the code phase shifts, there is a
12 drop in the level of the detection signals, and hence a lock
13 drop preventing acquisition of the channel signal. Hence, the
14 receivers automatically adjust the code phase of the replica
15 code to dynamically match the code phase of the incoming
16 channel signal so as to maintain code lock during continuous
17 reception of the channel signal. In the event the replica code
18 has a large code phase differential, coherently code phase lock
19 is lost, and the signal cannot be reconstituted nor detected.

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21 The use of spreading codes have long been used to isolate
22 channel signals so that only receivers with predetermined codes
23 can only receive channel signals spectrum spread by the
24 particular respective codes. In practice, each user or receiver
25 is assigned a priori a respective unique spreading code. In some
26 situations, a common channel signal can be broadcast to a
27 plurality of receivers all having the same identical spreading
28 code, such as in the broadcast of a GPS signal from a satellite

1 to a plurality of GPS receivers each having the same spreading
2 code for respective coherent reception. That is, the spreading
3 code is used to broadcast a DSSS channel signal to a group of
4 users all having a receiver generating a replica of the same
5 spreading code for receiving the broadcasted signal. Once the
6 grouped receivers are equipped with the same replica code, all
7 user receivers will receive the same information at all times.
8 In the presence of a jamming signal, all receivers will be
9 equally jammed and communications will be equally jammed
10 amongst all of the users. In clandestine or black out
11 communications, it may be desirable to send a communication to
12 a selected segment of the group and not to others of the group
13 at various times. Such selective communications can be used in
14 field operations where a first group is a friendly or desired
15 group of recipients and the second group is a hostile or
16 undesired group of recipients. Such selective communications
17 during the broadcast of a spread spectrum signal could be used
18 to communicate with the entire group at one time, and a
19 preferred portion of that group at another time. Conventional
20 broadcast spread spectrum communication systems using a single
21 spreading code prevents time variable selective communications
22 to a portion of a group of receivers. These and other
23 disadvantages are solved or reduced using the invention.

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Summary of th Inv ntion

An object of the invention is to provide a communication system that broadcasts upon transmission a channel signal using a plurality of spreading codes at respective different times for selective communication to a plurality of receivers.

Another object of the invention is to provide a communication system that broadcasts upon transmission a channel signal using a plurality of spreading codes at respective different times for selective communication to differing segments of the plurality of receivers at the respective different times.

Yet another object of the invention is to provide a communication system having a plurality of receivers for receiving a broadcast channel signal spectrum spread at different times by respective spreading codes.

The present invention is directed to a spread spectrum broadcast communication system that selectively communicates a spread spectrum channel signal by differing spreading codes at differing times to a group of receivers. A first portion of th receivers receive the channel signal at a first time using a first spreading code and a second portion of the receivers receives the channel signal at a second time using a second spreading code. In the pr ferred form, a transmitter transmits

1 a first channel signal at a first time period using a first
2 spreading code and transmits a second channel signal at a
3 second time period using a second spreading code, while, a
4 first portion of the receivers generate a replica of the first
5 spreading code for receiving the first channel signal during
6 the first time period and a second portion of the receivers
7 generate replicas of the first and second spreading code for
8 receiving the first channel signal during the first time period
9 and for receiving the second channel signal during the second
10 time period, respectively, using spreading code detection for
11 determining which spreading code is currently being used to
12 transmit the broadcast signal. In the preferred form, all of
13 the receivers receive and correlate the first channel signal
14 during a first time period, but only a portion of the receivers
15 receive and fully correlate the second channel signal during
16 the second time period. In this manner, the first message is
17 communicated in the first channel signal to all of the
18 receivers while a second message is communicated in the second
19 channel signal to only a subset of all of the receivers for
20 selective communications within a group of receivers. Hence,
21 the broadcast communication system can be used for sending
22 secret messages to a portion of a group of receivers at one
23 time and for sending public messages to the entire group at
24 another time. These and other advantages will become more
25 apparent from the following detailed description of the
26 preferred embodiment.

Brief Description of the Drawings

Figure 1 is a block diagram of a degraded spectrum spreading communication system.

Figure 2 is a dual code autocorrelation graph.

Figure 3 is a block diagram of spreading code detection receiver.

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Detail d Description of th Pref rred Embodiment

An embodiment of the invention is described with reference to the figures using reference designations as shown in the figures. Referring to Figure 1, a data source 10 provides messages in the form of sequence of data bits that are spectrum spread by a code spreader 12. A code generator 14 generates an original spreading code A during a first time period when the data source is providing a first message in the form of a first sequence of data bits, and, the code generator 14 generates an original spreading code B during a second time period when the data source 10 provides a second message in the form of a second sequence of data bits. The code spreader 12 spectrum spreads the first sequence of data bits that then modulates a carrier by the transmitter 16 that then broadcasts the first channel signal. The code spreader 12 spectrum spreads the second sequence of data bits that then modulates a carrier by the transmitter 16 that then broadcasts the second channel signal. Modulation of the carrier by a sequence of symbols encoded from the sequence of data bits for broadcast transmission is well known.

The broadcasted channel signal is received by a group of receivers 18 and 20. A first portion of receivers 18 of the receivers generate a replica spreading codes A and B respectively for both original spreading codes A and B for receiving the first and the second messages. A second portion of receivers 20 of th rec ivers only gen rate a replica of the

1 spreading code only for receiving only the first message. When
2 a receiver d spreads the channel signal using a replica cod
3 identical to the original code with coherent code phase over a
4 bit period, the autocorrelation is high so that the received
5 channel signal has a maximum received signal strength upon
6 which the receiver processes the received channel signal for
7 sequence data detection. When the original spreading code A is
8 used for spectrum spreading and the replica spreading code A is
9 used for spectrum despreading, there is a maximum A/A
10 correlation of the received signal. When the original spreading
11 code B is used for spectrum spreading and the replica spreading
12 code B is used for spectrum despreading, there is a maximum B/B
13 correlation of the received signal. When the original spreading
14 code A is used for spectrum spreading and the replica spreading
15 code B is used for spectrum despreading, with less than perfect
16 correction between the codes A and B, there is also a B/A
17 correlation of the received signal but with a lower maximal
18 correlation. The autocorrelation is degraded when the replica
19 code is not identical to the original code. When the first
20 portion of the receivers 20 use replica code B when the
21 transmitter is using original code A, the first group of
22 receivers cannot receive the first message. That is, the
23 degradation can be severe so as to prevent coherent code phase
24 lock, as well as losing carrier tracking and bit timing
25 tracking. Coherent code phase tracking using early and late
26 correlations, carrier tracking, and bit timing tracking are
27 well known.

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1 R ferring to all of the figures, and more particularly to
2 Figur 3, a spr ading code det ction rec iver is configured to
3 receive a channel signal spread by the two spreading codes A
4 and B. The channel signal S_C is received through an antenna 22
5 and despread by two or more spreading codes, though in the
6 exemplar form only two spread codes A and B are used. Multiple
7 spreading codes are used by time division in the transmitter
8 and hence are not concurrently used for spreading but are
9 concurrently used during reception. A spreading code A
10 generator 24a generates the replica spreading code A and a
11 spreading code generator 24b generates the replica spreading
12 code B, preferably at all times. The replica spreading codes A
13 and B are generally positively correlated with the original
14 spreading codes A and B, respectively, used to spectrum spread
15 the channel signal. The channel signal S_C is received through a
16 receiver antenna 22. The channel signal S_C is then concurrently
17 despread by code A using despreader 26a to generate received
18 signal S_A , and despread by code B using despreader 26b to
19 generate received signal S_B , at the front end of two receiver
20 channels A and B. The receiver channels respectively include
21 carrier controlling 24a and 24b, voltage control oscillators
22 (VCOs) 28a and 28b, and 90° phase shifter 30a and 30b, for
23 generating a sin and cosine replica carriers. The sin and
24 cosine replica carriers in channel A are used for coherent
25 demodulation of the carrier in I and Q quadrature using
26 demodulators 32a and 34a in channel A for respectively
27 generating an inphase I_A signal passed through a low pass filter
28 36a, and for generating a quadrature Q_A signal passed through a

1 low pass filter 38a. The sin and cosine replica carriers in
2 channel B are used for coherent demodulation of the carrier in
3 I and Q quadrature using demodulators 32b and 34b in channel B
4 for respectively generating an inphase I_B signal passed through
5 a low pass filter 36b, and for generating a quadrature Q_B signal
6 passed through a low pass filter 38b. Coherent carrier tracking,
7 VCO control, sin and cosine replica carrier generation, and
8 carrier demodulation are well known techniques. The I_A and Q_A
9 signals are fed into a channel A power detector 42a for
10 determining the average power of the I_A and Q_A signals as a
11 channel A power signal. The I_B and Q_B signals are fed into a
12 channel B power detector 42a for determining the average power
13 of the I_B and Q_B signals as a channel B power signal. The A and
14 B power signal are fed to a comparator that provide an A/B
15 signal indicating which of the two channels has the highest
16 power of the I and Q quadrature signals. The A/B signal is fed
17 into selector 46 that selects either the I_A and Q_A signals of
18 channel A or the I_B and Q_B signals of channel B, and the I and Q
19 output signal.

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21 In system operation, as the broadcast system switches from
22 the first to the second messages while concurrently switching
23 from using the spreading code A to using the spreading code B,
24 A channel power signal drops as the B channel signal increases,
25 which causes the comparator to toggle, such that, the I and Q
26 outputs of the selector switches from providing the I_A and Q_A
27 signals to providing the I_B and Q_B signals. Hence, the spreading
28 code detection receiver can receive both the first and second

1 m ssages. It should now be apparent that th code A receiver 20
2 can only r ceive the first message using th spreading code A
3 in a conventional manner, but that the code A or code B
4 receiver 18 can receive both the first message using the
5 spreading code A and the second message using the spreading
6 code B. In this manner, a broadcast message, such as the second
7 message, can be selectively received by one group of receivers,
8 such as code A and code B receivers 18, and not by another
9 group of receivers, such as the code B only receiver 20.

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11 The invention has selective jamming applications. A
12 communication system provides an information service to the
13 whole group of receivers while at the same time maintaining th
14 ability to nominally provide the information to the whole group
15 but deny certain information to unauthorized users in a
16 localized area, while assuring that the authorized users in
17 that localized area could continue to have access to the
18 broadcasted information. A broadcast signal is transmitted
19 using a single high powered code. All unauthorized users access
20 to a code, which only partially correlates with the satellites
21 code, while the authorized users get the code used by the
22 satellite. This partial correlation can be had by randomly
23 flipping a percentage of the bits, for example, one in thre ,
24 so that the desreading code is similar to but not exactly th
25 transmit spreading code. Under normal conditions, the
26 unauthorized code allows the unauthorized users to get enough
27 of the information of interest but at a greatly reduced power
28 level due to r duc d correlation. Given the pow r differential

1 available to the authorized and unauthorized user, a jamming
2 that at the carrier frequency would have enough signal so as to
3 affect the unauthorized user while not affecting the authorized
4 user.

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6 The ability to track a signal is related to the ratio of
7 the post correlation signal power to noise power. The signal to
8 noise ratio can be taken at various points in the receiver so
9 it is important to distinguish between the precorrelation
10 signal to noise and the post correlation signal to noise. The
11 authorized and unauthorized users have the same precorrelation
12 signal to noise because each is receiving the same input
13 signal. The code used by the unauthorized user is only
14 partially correlated with the incoming signal and as a result
15 the post correlation signal power of the unauthorized user is
16 only a fraction of the post correlation signal power of the
17 authorized user. The post correlation noise level would be the
18 same for both the authorized and the unauthorized user. Because
19 the post correlation signal level of the authorized user is
20 greater than that of the unauthorized user, a jamming signal
21 can then jam the unauthorized user without jamming the
22 authorized user having a higher signal to noise ratio. Hence,
23 broadcasting using the same code to two groups of receivers,
24 one group of authorized users using full correlation by using
25 the same transmitted code, and the other group of unauthorized
26 users using partial correlation by using a similar code that is
27 not exactly the same as the transmitted code, in the presence
28 of a jamming signal, would provide communications only to the

1 authorized group and not to the unauthorized group. When the
2 jamming signal is discontinued, both groups would then receive
3 the same information. In this way, a jamming signal could be
4 used to selectively communicate to one of the two receiving
5 groups.

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7 In the preferred exemplar form only two codes are used,
8 but other combinations of codes and receiver groups can vary.
9 The spreading codes used, the number of codes, and the number
10 of groups of receivers are design parameters in such a
11 selective broadcast system. The codes should be chosen so that
12 the separation in power between the correctly demodulated
13 signal and the incorrectly demodulated signal is maximized for
14 detection purposes. Those skilled in the art can make
15 enhancements, improvements, and modifications to the invention,
16 and these enhancements, improvements, and modifications may
17 nonetheless fall within the spirit and scope of the following
18 claims.

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